REMARKS

It is requested that the above amendments be entered prior to examination.

Attached hereto is a marked-up version of the changes made to the specification by the current amendment. The attached page is captioned "**Version with markings to show changes made.**"

Respectfully submitted,

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Version with Markings to Show Changes Made

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RECORDING MEDIUM, RECORDING APPARATUS AND RECORDING METHOD

This application is a Rule 1.53(b) Divisional of Serial No. 09/395,218, filed September 14, 1999 now USPN 6,359,846

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a data recording medium, a recording apparatus and to a recording method for recording information to this data recording medium.

2. Description of Related Art

Data recording devices for optically recording information, and particularly digital data, to a storage medium are commonly used as a convenient means of mass data storage.

Phase change optical discs are one type of optical data recording medium. To record to a phase change optical disc a semiconductor laser emits an optical beam to a spinning disc to heat and melt a recording film on the disc. The achieved temperature and the cooling process (rate) of the molten film can be regulated by controlling the power of the laser beam, thereby inducing a phase change in the recording film.

When laser power is high, the recording film cools rapidly from a high temperature state and thus becomes amorphous. When a relatively low power laser beam is emitted, the recording film cools gradually from a medium high temperature state, and thus crystallizes. The resulting amorphous parts of the recording film are commonly known as "marks," and the crystallized part between any two marks is known as a "space." Two-value binary information can thus be recorded using these marks and spaces. When a laser beam is emitted at a high power setting to form a mark, the laser is referred to as operating at "peak power."

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values stored for 4S5M and 5M4S are likewise corrected based on the measured edge intervals 323 and 324.

When these four settings are updated, the first pattern signal 301 is again recorded and the edge intervals are measured. This process is repeated until the difference between the normal interval and the measured edge interval is below a predetermined threshold level simultaneously for all four edge intervals.

When recording the first pattern signal is completed, a second pattern signal is recorded. Shown in Fig. 6 are second pattern signal 601, which is the output signal from the pattern signal generator 125; output signal 602 from the pulse generator 111; output signal 603 from the pulse moving circuit 110; and mark pattern 604 formed in the recording track of the optical disc 101 based on output signal 603. The first pulse settings 5S4M and 3S5M, and last pulse settings 4M5S and 5M3S in Fig. 5 (a) are then updated using the same method described above using the first specific pattern signal 301.

When recording the second pattern signal is completed, a third pattern signal is recorded. Shown in Fig. 7 are third pattern signal 701, which is the output signal from the pattern signal generator 125; output signal 702 from the pulse generator 111; output signal 703 from the pulse moving circuit 110; and mark pattern 704 formed in the recording track of the optical disc 101 based on output signal 703.

In Fig. 7 ~~[17, sic]~~, the 10T period of 710 and 711 (a 6T space and 4T mark) and the 10T period of 712 and 713 (*a 4T mark and 6T space ~~[10T space, sic]~~>> 712 is a 4T SPACE and 713 is a 6T MARK in Fig. 7*) overlap and appear as a continuous wave. Measured signal 710 - 711 and the next measured signal 712 - 713 therefore overlap, and it is difficult to accurately separate and analyze the measured signals. Utilizing the fact that jitter is minimized if the two 10T periods are substantially the same length, a jitter meter can therefore be substituted for measurement. Other than these signal

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periods, the same method used with the first pattern is applied to set and update the first pulse settings 4S4M and 3S3M, and last pulse settings 4M4S and 3M3S in Fig. 5 (a).

The conditions obtaining the least edge jitter with this third pattern signal and the correct edge interval time are the same. For example, if edge intervals 729 and 730 occur at the correct 9T time interval, jitter at a 9T edge interval will also be the lowest. Therefore, if either edge interval is offset from the normal 9T time, jitter at a 9T edge interval will increase.

When recording the third pattern signal is completed, a fourth pattern signal is recorded. Shown in Fig. 8 are fourth pattern signal 801, which is the output signal from the pattern signal generator 125; output signal 802 from the pulse generator 111; output signal 803 from the pulse moving circuit 110; and mark pattern 804 formed in the recording track of the optical disc 101 based on output signal 803. The first pulse setting 4S3M and last pulse setting 4M3S in Fig. 5 (a) are updated using the same method used with the first pattern signal.

When recording the fourth pattern signal is completed, a fifth pattern signal is recorded. Shown in Fig. 9 are fifth pattern signal 901, which is the output signal from the pattern signal generator 125; output signal 902 from the pulse generator 111; output signal 903 from the pulse moving circuit 110; and mark pattern 904 formed in the recording track of the optical disc 101 based on output signal 903. The first pulse setting 3S4M and last pulse setting 3M4S in Fig. 5 (a) are updated using the same method used with the fourth pattern signal.

It is therefore possible with the method according to this preferred embodiment to compensate during recording for the effects of heat accumulation and thermal interference during recording, and thus record a mark/space pattern with little jitter, by determining before data recording the mark start position from the length of the recorded mark and the length of the space preceding the mark,

Fig. 12 is a plan view of an optical disc 1201. In this exemplary embodiment user data is recorded to data area 1202. Information indicative of the method used to adjust the first pulse and last pulse according to the input data signal is recorded to area 1203 at the inside circumference area of the disc using a sequence of pits and lands (marks and spaces). Between the data area 1202 and adjustment method recording area 1203 is a test recording area 1204. Using this disc format, it is possible to determine whether recording is optimized by moving the first and last pulse positions, or by varying the first and last pulse width, by reading the adjustment method recording area 1203 before starting test recording.

Operation when an optical disc 1301 formatted as shown in Fig. 13 is loaded into a disc recorder as shown in Fig. 1 is described next below.

This optical disc 1301 has a user data area 1302 and an area 1303 for recording at the time of disc production either an optimized or typical pulse position value for either the leading or trailing mark edge. More specifically, area 1303 records either the first drive pulse position Tu or last drive pulse position Td value. Note further that area 1303 is recorded at the inside circumference of the disc using a sequence of pits and lands (marks and spaces).

When this optical disc 1301 is loaded into the disc recorder, the optical head moves to area 1303 to read the optimum position information for the leading and trailing mark edges. The read data signal 128 is then input to the ~~pulse position setting circuit 120 [NOTE: THIS IS~~ memory 129 ~~ABOVE]~~ and the optimum position information for the leading and trailing mark edges is set in the pulse moving circuit 110 via bus ~~120 [sic].~~

By thus reproducing the leading and trailing mark edge position information optimized for an input signal from area 1303 of the optical disc 1301 and setting up the disc recorder for recording based on this information, optimized recording can be achieved with optical discs having different formats and recording films without first performing the test recording operation described above.

3602, and 3603 are not generated on the same time base, for convenience they are shown with corresponding parts in each signal aligned vertically.

The pattern signal in this case represents marks and spaces with a simple 6T period, and thus contains types 5S5M and 5M5S of the eighteen pattern types shown in Fig. 5 (a). The laser is then driven based on drive signal 3603 in Fig. 36 to record the marks 3604. In this exemplary embodiment, pattern signal 3601 in Fig. 36 is repeatedly recorded around one complete circumference of the recording track. When this track is recorded, it is then reproduced. Reproduction includes converting an optical signal from the photodetector 108 to an electrical signal, and then processing this electrical signal with preamplifier 112, low pass filter 113, and reproduction equalizer 114. The reproduction signal 3605 from the reproduction equalizer 114 is applied to asymmetry measuring circuit 140 and digitizing circuit 115.

The digitizing circuit 115 adjusts the slice level signal 3609 so that the output level corresponding to a mark and the output level corresponding to a space in the output signal of the digitizing circuit are at equal intervals, and applies this slice level signal 3609 to the asymmetry measuring circuit 140.

The asymmetry measuring circuit 140 compares the average of the high 3611 and low 3610 peak values of the reproduction signal 3605 with the slice level signal 3609 ~~[3612, sic]~~. When the difference or ratio therebetween is outside a specified range, the peak power setting is off. The peak power setting is therefore adjusted according to the sign of this difference or ratio. This 6T pattern signal recording, reproduction, and asymmetry measurement loop is then repeated until the detected asymmetry is within a specific range.

The options shown in Fig. 38 are described further below.

In addition to the optimum or typical leading and trailing mark edge positions recorded to area 1503 of the optical disc 1501 shown in Fig. 15 during manufacture, the temporary power level information used for adjusting the leading

leading and trailing mark edge positions can be recorded. Note that this temporary power level information includes the specific peak power, specific bias power, margin constant, and asymmetry information.

When this optical disc is again loaded into the same disc recorder, area 1806 is read to obtain specific temporary power level information, such as the specific bias power setting. If the specific bias power setting is the same as the typical bias power setting recorded to area 1806, test recording for determining the specific peak power setting and adjusting leading and trailing mark edge positions according to the data can therefore be omitted, and the time required to determine the conditions for optimized recording can be shortened.

It is also possible in this case to quickly obtain the optimum temporary power setting using the information recorded to area 1806 ~~[1805, sic]~~ when the margin constant, asymmetry information, and other temporary power information recorded to area 1803 is unreadable due to a disc error, soiling, or other problem.

If information specific to the optical disc 1201, such as the disc manufacturer, product number, production date and location, disc format, and recording film type, is stored to area 1203 of the optical disc 1201 shown in Fig. 12 in addition to the adjustment method information, this disc-specific information and the temporary power level information (such as peak power, bias power, margin constant, asymmetry information) used for adjusting the leading and trailing mark edge positions can be stored to memory 130 of the disc recorder.

When this optical disc is then loaded, area 1203 is read to detect whether the disc-specific information is already in memory 130. If it is, test recording is then performed to determine the specific bias power level. The ratio between the typical peak and bias power level information in memory 130 is then obtained. This ratio can then be multiplied with the specific bias power level

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